ESTIMATION OF TIME PARAMETERS OF COAL PARTICLE COMBUSTION IN AIR FLOW UNDER THERMAL RADIATION

A. Ponomareva [1], K. Tcoi [2]

[1] *Institute of Applied Mathematics FAB RAS, Vladivostok*
[2] *Far Eastern Federal University , Vladivostok*

EFRE 2020

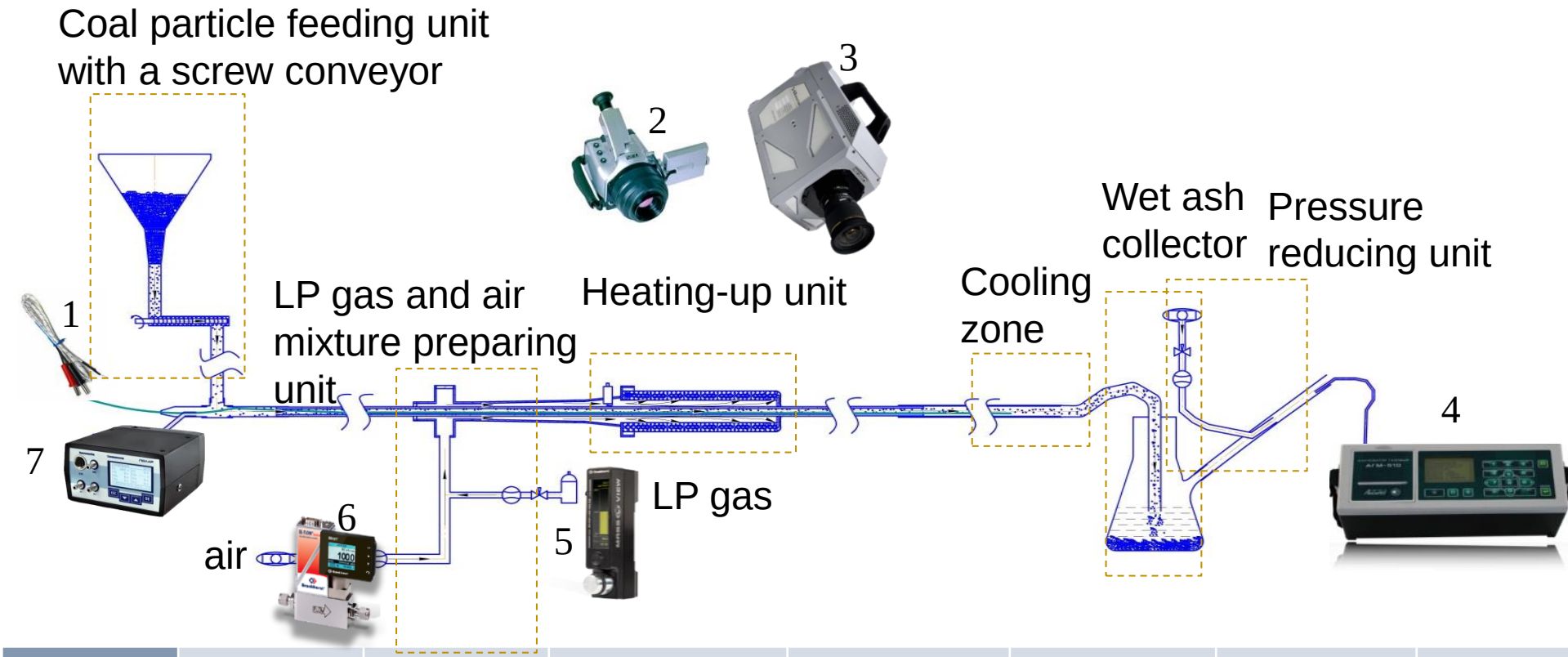
Poster N2-P-021201

Project №075-15-2019-1878

Preview

Short description: In this work, thermal behavior, and combustion properties of a coal dust of Pavlovskiy brown coal were studied. The investigation was focused on the estimation of time parameters of fine coal particles combustion using the data obtained during the experiments on the constructed laboratory-made setup. Experimental research parameters were applied for theoretical and numerical investigation. Calculated time parameters, such as heating-up time, yield and burning time of volatile, burning time of char, were compared with experimental data.

Units of laboratory setup



№	1	2	3	4	5	6	7
equipment	Thermocouple	Thermal Imager	High speed camera	Gas analyzer	Rotameter	Mass flow controller of air	Draft meter
parameters	Temperature range: −180 °C ÷ (+1300) °C	Temperature range: -40 °C ÷ (+2000)°C	Recording speed: 20,000 frames / sec	Detected gases: O_2, CO_2, CO, NO_x	Gas flow rate range: 0,2 ÷ 200 l/min	Air flow rate range: 8 ÷1670 l/min	Pressure range: -50 ÷ 50 hPa

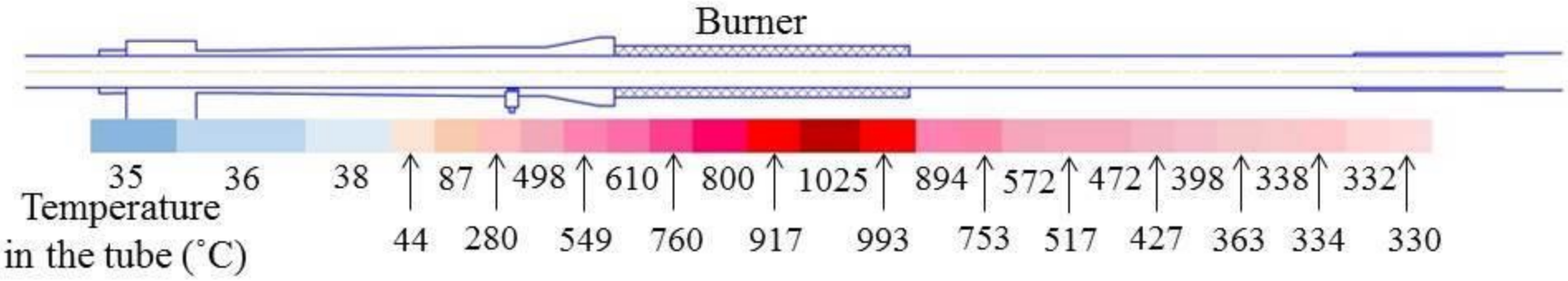
What can be varied:

- Flow velocity of coal particles
- Heat flux density from the burner
- Atmosphere inside the quartz tube

What can be measured or estimated:

- Real velocity of coal particles before and after the porous burner
- Heat flux falling on particles
- Approximate time of burning out for an individual particle
- Total mass change of all particles flew through a transport line (quartz tube)
- Chemical composition of outlet gases (at the end of the transport line)

Temperature inside the quartz tube for chosen regime



For the time parameters estimation, the regime was chosen when all coal particles were burnt out during flowing in the tube. The ash collector remained almost clear and contained only with light-coloured particles, which were further dried and weighed.

Description of the estimation procedure

To estimate the particle the time parameters of the coal combustion process we used common empirical dependencies*:

- *Heating-up time estimation*

$$\tau_h = k_h \cdot 5.3 \cdot 10^{14} \cdot {T_g}^{-4} \cdot \delta^{0.8}$$

where Tg – an ambient temperature, K; δ – an average initial particle size, m; kw – a relative coefficient determined experimentally for coal of each grade (for our brown coal the coefficient was taken as one).

- *Estimation of time of volatile release and combustion*

$$\tau_v = k_v \cdot 0.5 \cdot 10^6 \cdot \delta^2$$

where δ – an average initial particle size, m; k_v – an experimental coefficient determined experimentally for coal of each grade.

- *Char burning time estimation*

$$\tau_{ch} = \frac{100 - A_{ch}}{100} \cdot \frac{\rho_p \delta_0}{2\beta k_0 e^{-\frac{E}{RT}} C_{O_2}}$$

where k is an experimental coefficient characterizing the specifics of the burning of coal particles of a given grade; A_{ch} – an internal ash content of coal particle,%; CO_2 – a volume concentration of oxygen,%; δ – an average initial particle size, m; ρ_p – an apparent density of char, kg/m^3

*V.I. Babiy, Combustion of coal dust and calculation of a coal-dust torch, M .: Energoatomizdat, 1986.

Description of the estimation procedure

The combustion process description of a particle moving in an air stream is based on **the assumption** that small-sized coal particles acquire **a velocity close to the air velocity**. It's known, that under this condition, forced convective mass transfer is absent and the particle burns out uniformly.

For numerical estimations were used following **characteristics** of Pavlovskiy brown coal and **parameters** of experimental conditions:

average diameter of coal particles - 80 μm (was measured before),

ash content – 24.5 (was measured using standard procedure),

coal particle density – 1200 kg/m^3 (literature data),

temperature – 1300 K (experimental data),

coal particles moisture – 23% (was measured using standard procedure),

volatile yield – 60% (literature data),

decompression presure – -2hPa (experimental data).

Conclusion remarks

- Calculated times for the particle are 98 ms, 13.8 ms, and **17.5 ms** for heating-up process, stage of volatile release and combustion, and **char burning**, respectively. The **time parameter of whole combustion process** of one particle was estimated as about **129 ms.**
- Experimental data obtained have allowed to determined only the **total particle burning time** and time of volatile release and combustion of particles. The average values of this parameters for chosen experimental regime are **113 ms** and 16.5 ms, respectively. As was shown above these values are in a good agreement with numerical estimates.